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PROJECT INITIATION

Date: 6/28/71

Project Title: Tactical Expendable Assessment Study
Project No.: A-1340
Project Director: Mr. R. P. Zimmer
Sponsor: 4950th Test Wing (Technical), AFSC; Wright-Patterson AFB, Ohio
Effective: June 15, 1971 Estimated to run until: June 14, 1972*

Type Agreement: Contract No. F33615-71-C-1885 Amount: \$ 149,971.00
*Plus time for Final Report preparation, approval and distribution.

Reports Required: Program Schedule, Monthly Status Reports, Interim Technical Report, Presentation Materials, TRACE Report, Final Technical Report.

Sponsor Contact Persons: Technical Matters
Mr. Robert Rawhouser, AFAL/WRA
Project Engineer
Air Force Avionics Laboratory (AFSC)
Wright-Patterson AFB, Ohio 45433

Administrative Matters
Mr. R. J. Whitcomb (ACO)
OVR Resident Representative
Campus

Defense Priority Rating: DO-A7 under DMS Reg. 1.

Assigned to Electronics (Radar Branch) Division

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Engineering Experiment Station

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PROJECT TERMINATION

Date December 3, 1973

PROJECT TITLE: Tactical Expendable Assessment Study

PROJECT NO: A-1340

PROJECT DIRECTOR: Mr. R. P. Zimmer

SPONSOR: 4950th Test Wing (Tech.); Wright-Patterson AFB, Ohio

TERMINATION EFFECTIVE: 11-28-73 (Final Report submitted)

CHARGES SHOULD CLEAR ACCOUNTING BY: 11-30-73*

*Assuming one month N/C extension requested on 11-6-73 is granted.

CONTRACT CLOSEOUT ITEMS REMAINING: Final Invoice and Closing Documents
Final Report of Inventions
Government Property Inventory & Cert.
Classified Material Cert.

NOTE: Follow-on project is A-1492

RADAR DIVISION

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GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

A-1340

2 September 1971

Department of the Air Force
Air Force Systems Command
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Robert Rawhouser - AFAL/WRA
Air Force Avionics Laboratory

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 1
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 15 June through 31 July 1971 is contained herein.

The objectives of the work under this contract are to formulate and evaluate new expendable concepts, including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical or strategic missions.

The subject contract is a follow-on of Contract F33615-70-C-1727 and, as such, permitted the TEAS efforts to be continued without interruption. Hence, the application of the General Effectiveness Model (GEM) toward the evaluation of the various expendable concepts was continued under funding of this contract. The report on the investigations performed during this period is being prepared and will be part of the Final Report associated with the previous contract. It is anticipated that a rough draft of this Final Report will be completed by early August.

Efforts by TEAS personnel were devoted primarily toward evaluating various scenarios employing CHEAP-type expendables, Ground Based Jammers, and Guided Airborne Jammers relative to the use of on-board jammers. The implementation of the initial sub-model for analyzing linear distributions was completed prior to the investigations of scenarios employing CHEAP-type expendables. A description of this sub-model also will be presented in the Final Report.

Work funded by this contract during 15 June to 31 July was performed by the following professional personnel:

<u>Name</u>	<u>July Hours</u>
Adams, J. Dayton Research Physicist	119
Ecker, H. Allen Principal Research Engineer	17
Francis, O. B., Jr. Research Mathematician	118
Miller, Thomas M., Jr. Research Engineer	45
Pearl, Ronald G. Assistant Research Engineer	74
Sears, W. E., III Research Engineer	101
Zimmer, Robert P. Project Director	92

During August efforts by TEAS personnel will be devoted toward the continued evaluation of CHEAP-type and Guided Airborne Jammers. The expected cost of missions employing these expendable concepts will be determined as a function of the various payload parameters, and in addition the effect of deployment errors will be investigated. Preparation of the Final Report, which will include a report of the above investigations, will continue under the previous contract.

In addition to the above, efforts during August will be on the preparation of a detailed Program Plan for the TEAS efforts to be performed

Department of the Air Force
Monthly Status Report No. 1
Contract F33615-71-C-1885

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during the contract period. It is anticipated that this plan will be submitted to AFAL by mid-September.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. A. Ecker
Head, Radar Branch

RPZ:jf



EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

A-1340

29 September 1971

Department of the Air Force
Air Force Systems Command
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Robert Rawhouser - AFAL/WRA
Air Force Avionics Laboratory

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 2
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 August through 31 August 1971 is contained herein.

The objectives of the work under this contract are to formulate and evaluate new expendable concepts, including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical or strategic missions.

During August work continued on the application of GEM toward the evaluation of the various expendables, as well as on the preparation of the draft of the Final Report. Emphasis in the evaluation effort was on the application of GEM to multiple-aircraft/multiple-sites. Based on tactics and aircraft load configurations described in the report "Tactical Aerial Weaponry Mission Analysis" AFSC West Coast Study Facility, an example was selected which incorporated expendable countermeasures. Its purpose was mainly to demonstrate the use of GEM in analyzing tradeoffs involved in adding additional aircraft to a strike force to accommodate additional ECM capability. A description of this approach as well as the results associated with the example are presented in the Final Report.

It should be mentioned that during the process of selecting the details for the multiple-aircraft/multiple-site example, TEAS personnel became increasingly aware of the need for more information on philosophies and techniques which mission planners might use in actual situations. Such information is especially important since ultimately the user commands must be convinced of the desirability of expendable countermeasures.

Preliminary detailed plans were made for the TEAS efforts to be performed during the contract period. These plans will form the basis for the Program Schedule to be submitted to AFAL in September.

Effort Expended

Work during 1 August through 31 August was performed by the following professional personnel:

<u>Name</u>	<u>August Hours</u>	<u>Cumulative Hours</u>
Adams, J. Dayton Research Physicist	70	189
Ecker, H. Allen Principal Research Engineer	70	87
Francis, O. B., Jr. Research Mathematician	84	202
Miller, Thomas M., Jr. Research Engineer	95	140
Pearl, Ronald G. Assistant Research Engineer	88	162
Sears, W. E., III Research Engineer	158	259
Zimmer, Robert P. Project Director	99	191

Visits

On 30 August 1971, Mr. Ronald Pearl of Georgia Tech visited Mr. Floyd Pirie and Mr. Robert Rawhouser of AFAL in order to provide presentation material for possible use in a briefing to be given by AFAL to the Scientific Advisory Board. The draft copy of the TEAS Final Report as well as future plans of TEAS were discussed. The importance of taking into account deployment errors in the evaluation of the various expendable concepts was emphasized. Also discussed were the interface efforts with the various simulators.

Future Work

During the next month, efforts will be devoted toward program planning, data gathering, and model extension and improvement. The various expendable concepts to be investigated during this program will be closely examined to determine the priorities of the various sub-models of GEM that should be developed. This preliminary investigation will be done in view of the current capabilities of GEM together with the anticipated scenarios that will be used for analysis purposes. It is apparent that additional data are needed regarding mission planning and threat radar operator techniques and doctrines. Data requests will be prepared in an effort to obtain information about the various subject areas.

As was done for the previous TEAS contract, the reporting period of future monthly status reports will be a calendar month rather than the 15th to 15th as implied in the contract. The reporting period of a calendar month coincides with the accounting period of Georgia Tech; and consequently for a given calendar month, information concerned with budgeting and personnel would be available for inclusion in the Status Report for that month.

Respectfully submitted,

Robert P. Zimmer ✓
Project Director

Approved:

H. A. Ecker
Head, Radar Branch

RPZ:jf

A-1340



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

5 October 1971

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Robert Rawhouser
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 3
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 September through 30 September 1971 is contained herein.

The objectives of the work under this Contract are to formulate and evaluate new expendable concepts including associated techniques for delivery, deployment and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical or strategic missions.

Work continued on formulating plans for the TEAS program and a Program Plan was prepared and sent to AFAL. As described in the Plan, the efforts of TEAS personnel will be devoted to work in three task areas: TEAS program interface, model extension and improvement, and application of GEM in the evaluation of expendable concepts. The first two areas were emphasized during September.

The various sub-tasks of TEAS were examined to determine data that possibly would be needed during the TEAS program. In view of the existing data at Georgia Tech, a list of the more pertinent data was prepared and forwarded to AFAL. Additional data requests will be made periodically as part of our efforts on the TEAS Program Interface task.

A study was begun to determine the primary parameters or factors which would be inherent in any "doctrine" with which a threat radar operator selects and tracks a given strobe over another. Documents from Cornell Aerosnautical Laboratories and AFAL were scrutinized. From these documents, it appears that the primary parameters are relative intensity, relative

velocity, and spatial separation of the two strobes; also of primary importance is whether or not the strobes of an expendable match those of an aircraft. Although these are believed to be the primary parameters, additional data needs to be obtained before a doctrine relating these parameters can be formulated for use in GEM. In an attempt to obtain more data, visits will be made to facilities where tests involving simulated threat radars are being conducted.

Work continued on the development of the adaptive time increment model for use in decreasing the running time of the GEM program. In general, with this model, certain important events of the scenario are determined and appropriate time increments are established for each portion of the mission. Parameters associated with these events and anticipated for use in this model include 1) the time at which each flight leg begins; 2) the time at which target azimuth or elevation angles are the same as those of jammers; 3) the flight time of SAMS; and 4) the rate of change of radar cross section. Relationships among these parameters have been established and implementation into a computer program has started.

A preliminary investigation was made of the optimization techniques that might be desirable for use in the application of GEM toward the evaluation of expendable concepts. A review was made of the type of equations used in GEM, the type of problems that GEM could be used to solve, and the input variables necessary for GEM to operate properly. Based on this review, it was determined that the input variables can be divided into three groups according to the three methods commonly employed for determining the values for these variables that correspond to minimum expected cost. These methods are analytic, which involves using gradient techniques on appropriate equations; numerical optimization, for use with those variables to which gradient techniques cannot be employed and that result in only one extremum in expected cost; and parameterization, which is used when very little can be ascertained a priori about a given variable. It is anticipated that results that are obtained using optimization techniques will be sensitive to various operator doctrines as well as to deployment errors that are associated with the delivery and dispensing of expendables. In view of other high-priority sub-models that must be developed together with anticipated outputs from optimization techniques, it was decided to postpone the development of any automated numerical optimization routines for possible use with GEM. Instead, optimization efforts will be parameterization studies of the most important variables.

Computer programming efforts during the past month were concerned with improving the sub-model for analyzing LINE CHEAP, implementing the Early Warning Sub-Model to work with the SAM Sub-Model, and in implementing improved sub-routines for printing out computer running times associated with the various sub-routines of GEM.

Effort Expended

Work during 1 September through 30 September 1971 was performed by the following professional personnel:

<u>Name</u>	<u>September Hours</u>	<u>Cumulative Hours</u>
Adams, J. Dayton Research Physicist	97	286
Ecker, H. Allen Principal Research Engineer	34	121
Francis, O. B., Jr. Research Mathematician	34	236
Miller, Thomas M., Jr. Research Engineer	121	261
Pearl, Ronald G. Assistant Research Engineer	116	278
Sears, W. E., III Research Engineer	114	373
Zimmer, Robert P. Project Director	161	352

Visits

On 9 September 1971 Mr. Russ Porter of OSD/ODDR&E visited Georgia Tech to review the TEAS program, and a presentation was given by Dr. H. Allen Ecker with other TEAS personnel present. Mr. Porter indicated the desirability for data which could be used to construct expendable countermeasures tables for use by mission planners and pilots. He also indicated that since missions currently involve support aircraft, we should consider the possibility of carrying expendables on aircraft designated specifically as threat suppression. Otherwise, designating a "new task" requiring additional aircraft may not be well received by mission planners. He felt that the F-15 should be analyzed along with current on-board jammers. In addition, he indicated a desire for us to consider predetonation of fuses using either jamming or chaff, and also in defeating the home-on-jam capability of SAMS.

On 23 September 1971 Mr. Walter Schwartz of Electronic Resources/Tasker Industries, visited Georgia Tech to talk about the JUNGLE JAMMER and related concepts. He gave about a 2-hour presentation showing view graphs on operational concepts and some details of operation.

Future Work

During October work will continue on gathering data that can be used in the formulation of doctrines associated with moving strobes. TEAS personnel will visit the RBS facility at Statesboro, Georgia to witness tests involving the operation of simulated threat radars in an ECM environment and to interview radar operators. If sufficient data and information are gathered, the various doctrines will be formulated probabilistically for incorporation into GEM. Also, as part of the data gathering task, Mr. Robert Zimmer will visit Nellis Air Force Base to speak with mission planners; he will also attend a Symposium in Los Angeles sponsored jointly by the Air Force and JPL entitled "The Air Force in 1980."

Development work will continue on a deployment error analysis routine to be incorporated in GEM. It should be pointed out that very little information is available at Georgia Tech on deployment errors associated with the various vehicles considered as candidates for delivering expendable countermeasures. A request concerning this desired information will be prepared and sent to AFAL.

Respectfully submitted, ,

for Robert P. Zimmer
Project Director

Approved:

H. A. Ecker
Head, Radar Branch

RPZ/lng

LIBRARY DOES NOT HAVE :

Monthly Status Report no. 4



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

A-1340

6 January 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Robert Rawhouser
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 5
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 November through 30 November 1971 is contained herein.

The objectives of the work under this Contract are to formulate and evaluate expendable concepts including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical missions.

Modelling

During November efforts were devoted toward developing techniques for including the effects of deployment errors in the evaluation of expendables whose deployment has errors associated with them. The generalized effectiveness model (GEM) computer program was modified and expanded so as to include the routines for deployment error analysis. In general the deployment error analysis routine involves the determination of the expected cost associated with selected expendable positions, together with the probability that the expendable is deployed at each position. This probability is used to weight the corresponding expected cost and the weighted average is computed. In using the routine, distributions of errors can be defined in up to four dimensions of position and time. Currently all error distributions are assumed to be Gaussians. Other distributions will be used if and when adequate data become available on the various delivery systems.

Other work during November included the development of several of the routines necessary for drum storage of the multiple radar sites. The programming was completed and tested. In addition, efforts were devoted

toward deriving mathematical equations for the computation of aircraft pitch and roll during an attack flight profile. In the current version of GEM, the aircraft is modelled as flying horizontally during a mission. Such a model is realistic for a cruise flight profile but may give rise to inaccuracies associated with an attack profile. These investigations will provide information on the sensitivity of expected cost to aircraft pitch and role.

Interaction

On 1 November 1971, H. A. Ecker, Robert Zimmer, and Ronald Pearl visited AFAL to give a presentation on the TEAS program. Dr. Ecker presented a series of viewgraphs covering objectives, approach, the General Effectiveness Model (GEM) block diagram, sensitivity analyses, and examples of the type of results obtainable from TEAS. Necessary interaction among the various agencies was emphasized and future plans were discussed. Attendees at the meeting included W. Eviston, W. Portune, G. Helgeston, P. Seaton, F. Pirie, Lt. M. Herrera, and John Burda.

On 30 November, 1971 H. A. Ecker, R. P. Zimmer and R. G. Pearl visited John M. Porter, OSD/ODDR & E, to present a summary of the work done during the first year on the TEAS program. Other attendees were Major E. Martin from Headquarters USAF, R. Rawhouser and F. Pirie, from AFAL and Col. Lester and Fred Eimer of DDR & E. This briefing included summaries of the GEM model, the sensitivity analysis, typical results, and future plans emphasizing the need for interaction with the various elements of TAC, SAC, Systems Command etc. During the briefing, discussions were concerned with the capacity of GEM, the validity of certain operator model formulas, the EW/GCI capability, pseudo-random noise and doppler-shift repeaters. After the briefing the Coronet Organ tests were discussed. Mr. Porter believed that the methodology presented could be put to use in determining what expendables should be used and how they should be used for some future Coronet Organ tests.

Effort Expended

Work during 1 November through 30 November was performed by the following professional personnel:

Effort Expended (continued)

<u>Name</u>	<u>November Hours</u>	<u>Cumulative Hours</u>
Adams, J. Dayton Research Physicist	162	589
Ecker, H. Allen Principal Research Engineer	37	183
Francis, O. B., Jr. Research Mathematician	88	395
Greneker, E. F. Assistant Research Scientist	35	35
Miller, Thomas M., Jr. Research Engineer	141	538
Pearl, Ronald G. Assistant Research Engineer	144	545
Sears, W. E., III Research Engineer	148	667
Zimmer, Robert P. Project Director	155	650

Future Work

During December, work will continue on expanding GEM to handle more complex scenarios. This involves extensive reorganization of the current GEM program (GEM-1) so that a new GEM program (GEM-2) will be developed. The deployment error analysis routine will be completed for incorporation into GEM-1 so that analyses can be performed with GEM-1 while GEM-2 is being developed.

Sensitivity analyses will continue with emphasis during December being on investigation of the Scenario Sub-Model. In particular, the approximation used in representing antenna patterns in digital form will be studied closely in an effort to determine how many data points are required.

Air Force Avionics Laboratory (WRA)
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Page 4

Future Work (continued)

Other techniques associated with the use of the antenna patterns in calculating the appropriate gain will be examined.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. A. Ecker
Head, Radar Branch

RPZ/bp

LIBRARY DOES NOT HAVE :

Monthly Status Report nos. 6 and 7



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

A-1340

6 April 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Leonard Brown
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 8
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 February through 29 February 1972 is contained herein.

The objectives of the work under this contract are to formulate and to evaluate expendable concepts including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical missions.

General Effectiveness Model (GEM) Efforts

During February, efforts on GEM were concerned with refining and validating formulations associated with modeling threat radar operators. Particular emphasis was on modeling interactions between early warning, acquisition, and track-while-scan radar operators. The formulations developed during February were primarily associated with the acquisition module. Inputs to this module include display information such as the total number of strobes and targets; the power and position of credible targets and strobes; and position, size, velocity and type of false targets and strobes.

To support the development of a model to predict a radar operator's average performance when targets are in a chaff environment, a series of tests using the SATSIM at AFAL has been requested. These tests will be conducted to gather statistical data on operator performance for use in validating and refining various modules of GEM, and will involve model parameters such as J/S ratio, chaff spacing, chaff RCS, target velocity, number of strobes, etc. Preliminary plans for these anticipated tests are being prepared.

Interaction

On 3 February 1972, Dr. H. A. Ecker and Mr. R. P. Zimmer of Georgia Tech visited AFAL/WRA-1 and met with Messrs. Paul Seaton, Floyd Pirie, Leonard Brown, Robert Rawhouser, and Capt. Miller. Items discussed include the following:

1. A visit to Tactical Air Command, Headquarters (TAC, Hdq) to discuss possible roles that the TEAS program might have in large scale exercises conducted by TAC;
2. A briefing on the TEAS program to Mr. Phil Sandler of the Air Force Systems Command Headquarters;
3. Use of the SATSIM and EDE simulators to obtain inputs to the GEM model; and
4. The Final Report for TEAS, Phase I.

On the afternoon of 3 February, Messrs. Pirie, Brown, and Zimmer visited the intelligence office of the Aeronautical Systems Division to establish contacts for obtaining additional information on the threat scenarios. The next morning, Georgia Tech and WRA-1 personnel met with Mr. William Eviston and Mr. George Maxwell of WRD to discuss the TEAS program.

On 9 February 1972, Mr. W. R. Karmazin and Mr. Edward Sader of Northrup Corporation and Mr. David Wallace of Pinson Associates, visited Georgia Tech to discuss expendable delivery systems and to learn about the TEAS program.

On 21 February 1972, Mr. Walter Schwartz of Tasker/Electronic Resources visited Georgia Tech to supply updated information on JUNGLE JAMMER concepts and on the Steerable Electronic Airborne Jammer (SEAJ) concept.

Application of GEM

During February emphasis was placed on the check-out of the deployment error subroutine developed for GEM. The approach in calculating the deployment error has been to assume a Gaussian distribution of error along an axis and to form a weighted expected cost based on the area under the corresponding Gaussian density function. Since the axis along which the error is Gaussian is divided into intervals, the appropriate number of intervals, as well as the spacing between intervals must be specified. Investigations were made to determine the sensitivity of expected cost to the size and number of intervals. In general, this sensitivity will depend upon the nature of the variation of expected cost for the case of zero error.

Preliminary parametric analyses were made of area chaff using the GEM-1 program, modified to include the area chaff subroutine. Parameters investigated included the radar location, aircraft altitude, position and size of the chaff cloud, and chaff density. These analyses were performed for one-on-one scenarios and considered chaff from the viewpoint of screening an aircraft.

Effort Expended

Work during 1 February through 29 February was performed by the following professional personnel:

<u>Name</u>	<u>February Hours</u>	<u>Cumulative Hours</u>
Adams, J. Dayton Research Physicist	-	856
Ecker, H. Allen Principal Research Engineer	34	266
Francis, O. B., Jr. Research Mathematician	109	689
Greneker, E. F. Assistant Research Scientist	131	395
Miller, Thomas M., Jr. Research Engineer	142	924
Pearl, Ronald G. Assistant Research Engineer	136	948
Sears, W. E., III Research Engineer	141	1044
Zimmer, Robert P. Project Director	141	1050

Future Work

During March, work will continue on the development of probabilistic formulations associated with modeling early warning, acquisition, and track-while-scan radars with particular emphasis on modeling the interaction between the various radar operators. These formulations when suitably developed will be implemented in the GEM computer program.

Detailed plans will be prepared for the tests to be conducted for WRA-1 on the SATSIM. These plans will include specifying appropriate flight profiles and chaff masks for the tests as well as determining a desirable sequence of tests. Results of these tests will be used in the development of GEM.

Analyses using GEM-1 will be made of one-on-one situations involving chaff and CHEAP expendables as might be delivered from TPAR. The threat radar will be different in the various analyses, and selected early warning, acquisition, and track-while-scan radars will be studied. Also, preliminary one-on-one analyses will be made using SEAJ (Steerable Electronic Airborne Jammer) as a payload.

In addition to the above, the Final Report of TEAS, Phase I will be modified according to the instructions given by AFAL. The printed copies should be available by mid-April.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. Allen Ecker
Chief, Radar Division

RPZ:jf

A-1340



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest Atlanta, Georgia 30332

14 April 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Leonard Brown
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 9
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 March through 31 March 1972 is contained herein.

The objectives of the work under this contract are to formulate and to evaluate expendable concepts including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical missions.

General Effectiveness Model (GEM) Efforts

Modeling efforts for March included completion of data base routines in GEM II, development of the Basic Operator Performance module, and planning of the Target-in-Chaff Acquisition module which will be validated upon completion of the SATSIM tests currently underway.

The completion of the "radar data" routines involved collecting all pertinent data on threat radars currently selected for analysis and implementing into GEM the routines containing these data. For each radar the routines contain the value of each parameter, its units, and whether or not the value has been verified. If any data for a certain radar is not verified and that radar is used in GEM II, a message to that extent is printed. Similar routines for the parameters of aircraft and all expendables are being implemented.

Mathematical derivation of the Basic Operator Performance module was completed in March. Formulation of this module was derived on the basis of the definition of the two events which must occur in the performance of any human operator task. These events have been designated as intent (making the

decision to attempt to accomplish a task) and success (successfully accomplishing the task). The formulation is general in nature and, as such, will form the basis for model formulation of most tasks defined for radar operators as well as for filter center personnel. The routine for the Basic Operator Performance module will be implemented in GEM II and sensitivity analyses will be performed.

Initial plans have been made for formulating the relationships between the representation of chaff in the Scenario Sub Model and the Target-in-Chaff Acquisition module. Chaff pattern parameters have been defined and the routine for converting from scenario parameters (RCS, bloom rate, fall rate, etc.) to display powers (power received, dot size, positions, etc.) will be implemented.

Interaction

Approval was given for a series of tests to be run for WRA-1 using SATSIM and in support of the TEAS program. In anticipation of these tests, a planning meeting was held on 6 March 1972 at AFAL. Attendees were Messrs. Robert Zimmer, Ronald Pearl, and Eugene Grenaker of Georgia Tech; Leonard Brown and George Maxwell of AFAL; and David Wallace and Charles Sigley of Pinson Associates. In general the purpose, approach, scope, and details of the tests to be run were discussed. Currently, the tests are scheduled for the duration between March 29 and May 19. An internal memorandum was written describing some of the details of the plans resulting from these discussions.

On 16, 17 March 1972, Mr. Robert Zimmer of Georgia Tech and Mr. Leonard Brown of AFAL/WRA attended an Old Crows meeting at Eglin Air Force Base, Florida. The principal subject of this meeting was a description and demonstration of the MISSION PLANNER, a software capability developed by Litton Industries and sponsored by Rome Air Development Center (RADC). On Thursday afternoon, Mr. Robert Ragazzo of RADC/RAP gave a presentation describing some of the aspects of the MISSION PLANNER, and on Friday morning a demonstration of it in operation was given. The MISSION PLANNER currently consists of two output displays--graphic and alpha-numeric--and a software computer program. The graphic display provides a visual map of the scenario under consideration and the alpha-numeric display provides quantitative data on the mission itself. Features of the MISSION PLANNER include essentially all of the functions or steps that might be taken during the planning of a tactical mission. These steps include selection of the scenario, ordnance tradeoff, resource allocation, route selection, safety considerations, on-board jamming, fuel and refueling considerations, and standoff jamming.

On Friday, Mr. Brown and Mr. Zimmer visited with Mr. John Lindegren of ADTC/TGYZ to learn about his work associated with the F-111A. Reports were shown to us that included dynamic radar cross-section data and on-board

jammer antenna patterns that are associated with the F-111A. On Friday afternoon discussions were held with Lt. Col. Roche of the Tactical Air Warfare Center (TAWC/TEW). Discussions centered around planning aspects of CORONET ORGAN exercises, and on the availability of radar cross-section data on the F-4. Radar cross-section data taken dynamically on the Eglin range, for both vertical and horizontal transmit polarizations, were shown to us as part of the COMBAT CLOAK reports. It was pointed out by Col. Roche that the project officer for the CORONET ORGAN tests at Eglin Air Force Base is Lt. Col. Dunmeyer (EWC/TAX).

On 27, 28 March 1972, Mr. Leonard Brown and Mr. Robert Rawhouser of AFAL visited Georgia Tech to discuss the TEAS program. During the first day, a presentation was given by Mr. R. P. Zimmer that essentially reviewed the objectives, scope, approach, and results associated with the first year's work on TEAS. On the second day, presentations were given by Messrs. Ronald Pearl, William E. Sears, III, and Thomas Miller on details of the modeling efforts, SATSIM tests, and analysis results recently obtained.

On 30 March 1972, Mr. Ronald Pearl of Georgia Tech visited Mr. Charles Sigley of Pinson Associates at AFAL. The purpose of the visit was to monitor the beginning of the SATSIM tests. Decisions on the order of tests and choices of chaff densities were made.

On 31 March 1972, Mr. Robert Annen and Mr. Charles Holly of Lundy Electronics and Systems, Inc. visited Georgia Tech to brief us on the new configurations of chaff and the latest dispensing techniques.

Application of GEM

During March one-on-one analyses were made to determine the relative effectiveness of low cost expendables, chaff, and Anti-Radiation Parafoils or Parawings (ARPS). In these analyses, the baseline flight profile is straight and level at an offset distance of 5 nmi from the radar, an altitude of 18,000 feet, and a velocity of 460 knots. An area type of expendable distribution pattern was considered, and uniform power density was assumed. Chaff was considered from only a screening viewpoint. The analyses using ARPS are quite preliminary in form, and additional investigations will be made that take into account errors in deployment.

In addition to the above work, modifications were made on the Final Report of TEAS, Phase I in accordance with the instructions given by AFAL. Except for Photo Lab work, all work on this report has been completed.

Effort Expended

Work during 1 March through 31 March was performed by the following professional personnel:

<u>Name</u>	<u>March Hours</u>	<u>Cumulative Hours</u>
Ecker, H. Allen Principal Research Engineer	28	294
Flynt, Edward R. Principal Research Engineer	37	37
Francis, O. B., Jr. Research Mathematician	120	809
Greneker, E. F. Assistant Research Scientist	138	533
Miller, Thomas M., Jr. Research Engineer	98	1021
Pearl, Ronald G. Assistant Research Engineer	171	1119
Sears, W. E., III Research Engineer	169	1213
Zimmer, Robert P. Project Director	158	1208

Future Work

As a result of the trip to Eglin Air Force Base on 16 March 1972, reports containing detailed dynamic RCS data on the F-4 and F-111A aircraft have been ordered. Also ordered were reports giving dynamic antenna patterns of certain on-board jammers. This data when received will be used to update and expand the data files of GEM. Other pertinent updated data on threat radars, such as antenna patterns, also will be put into a form for use by GEM.

In April, tracking capabilities associated with Early Warning and Surface-to-Air missile radar systems will be formulated and to some extent implemented in GEM. The basis for these formulations will be the Basic Operator Performance

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module. The various doctrines associated with message sending between the Early Warning and tracking radars will be implemented in GEM.

Preparation will begin of a report describing some of the analysis results. In addition, preliminary investigations will be made into the use of a drone as a delivery vehicle for selected expendables.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. Allen Ecker
Chief, Radar Division

RPZ:jf

A-1340



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest Atlanta, Georgia 30332

20 June 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Leonard Brown
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 10
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 April through 30 April 1972 in contained herein.

The objectives of the work under this contract are to formulate and to evaluate expendable concepts including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical missions.

General Effectiveness Model (GEM) Efforts

During April modeling efforts were devoted toward (1) continued formulation and implementation of all modules of the Operator Sub Model for Early Warning/Acquisition and Surface-to-Air missile radars; (2) initial sensitivity analyses associated with the Basic Operator Performance Sub-module; (3) continued monitoring of WRA-1 SATSIM tests; and (4) formulating and programming an adaptive time increment subroutine.

As indicated in Monthly Report No. 9, the GEM Operator Sub-Model includes the Basic Operator Performance (BOP) Sub-module which is concerned with the algorithms involving probabilities of intent and success for an operator task as a function of time.

The formulations associated with the task modules of the Operator Sub-Model primarily involved use of the Basic Operator Performance Sub-module together with algorithms reflecting operator performance. These various algorithms and task modules are currently being implemented into the GEM computer program.

The sensitivity of the output of the BOP Sub-module was investigated for various values of internal parameters. In these investigations steady-state probabilities were of interest along with the median time delays in reaching the steady-state conditions.

The formulation and implementation of the basic adaptive time increment subroutine has been completed. This subroutine determines for each radar the minimum sampling (look) time that would yield the same results as smaller, more time consuming, increments. For determining the sample rate associated with each radar, the particular radar is assumed to be at any given time in one of three modes. The modes are (1) the target is out of range of the radar, (2) the target is within range of radar, and (3) for terminal threats, the target is within range of missiles or guns. The subroutine has been programmed such that the optimum sampling time is one of the three basic sample rates assigned to each type of radar. The program automatically selects among these three possible times the value that is appropriate for the particular mode and radar type.

Interaction

On 7 April Mr. F. Lee Collins of ASD and Mr. Michael Wolfe of Maxson visited Georgia Tech to discuss the QRC-552 program. A presentation was given by Mr. Collins on the results of the chaff cloud tests and Mr. Wolfe discussed various characteristics, including cost-accuracy tradeoffs, associated with the BULLPUP rocket.

On 24 April Mr. Robert Zimmer visited Wright-Patterson AFB to obtain information on drones or RPVs. Of particular interest was information on types planned for tactical missions, radar cross section, accuracies, operational tactics, support equipment for recovery, etc. Mr. Zimmer and Mr. Brown (AFAL/WRA) in considering the drone as a possible delivery vehicle for expendables, spoke with Mr. George Maxwell of WRD, with Lt. Col. Kellerstrauss of ASD/RWD-PP, and with Mr. Jim Walters of ASD/XRL. In the afternoon, Mr. Zimmer and Mr. Brown met with Mr. Joe Meli and others from ASD/ENVEB to discuss the TEAS program.

On April 25, Mr. R. G. Pearl visited Wright-Patterson AFB for the purpose of reviewing initial data from SATSIM tests. The purpose of the SATSIM test currently underway is to determine the form of the "acquisition in chaff" module of the EW/GCI operator model. Results thus far indicate that the majority of the planned tests would be completed on schedule. Scan-to-scan raw data collected from each run is being delivered to Georgia Tech in the form of punched cards. This data will be used for a more detailed analysis of operator performance to be used in refining the operator sub-model.

Application of GEM

During April preliminary runs using GEM-I were made for one-on-one scenarios in which corridor deployments of chaff and mini-jammers were considered to be established by drones. Parameters investigated included deployment accuracies, altitude of deployments, and cost-accuracy trade-offs. These analyses concerning the drone as a delivery vehicle for expendables will serve as a basis on which to plan future investigations of the drone.

Other work in addition to the above included the preparation of a revised TRACE report corresponding to the Final Report on the first year of the TEAS program. Also, printing and binding of the Final Report were completed and copies mailed to the various agencies.

Effort Expended

<u>Name</u>	<u>April Hours</u>	<u>Cumulative Hours</u>
Ecker, H. Allen Principal Research Engineer	24	318
Flynt, Edward R. Principal Research Engineer	32	69
Francis, O. B., Jr. Research Mathematician	144	953
Greneker, E. F. Assistant Research Scientist	90	623
Miller, Thomas M., Jr. Research Engineer	107	1128
Pearl, Ronald G. Assistant Research Engineer	134	1253
Sears, W. E., III Research Engineer	102	1315
Zimmer, Robert P. Project Director	141	1349

Future Work

During May efforts will be directed primarily toward completing the current version of GEM-II. These efforts will include formulation and implementation of

modules associated with the Operator Sub-Model. A detailed checkout of the GEM-II program will be made in June and in July analyses using GEM-II will begin.

Concurrent with the above modeling efforts will be work devoted toward incorporating into GEM the dynamic RCS data on the F-4. These data are those recommended by the Tactical Air Warfare Center (TAWC/TEW) and include RCS data for vertical and horizontal polarization at three different frequencies. In addition to entering this new data into GEM, all data associated with pertinent radars and expendables will be checked for completeness, validity, and program accuracy.

Analysis efforts will be concerned with completing the preliminary look at the drone for use as a delivery vehicle. In addition, while GEM-II is being completed, a preliminary analysis will be made of a missile fuze expendable jammer.

Interim Technical reports will be prepared on the preliminary investigation of area expendables that essentially was completed in March, on the preliminary analysis of missile fuze jamming, and on the preliminary consideration of using a drone as a delivery vehicle for expendable. These reports should be completed by July. In addition, internal memoranda on the Operator Sub-Model are being prepared so that details of the Sub-Model will be documented and readily converted into a technical report.

Georgia Tech has been invited to present a paper on RPVs at the "Symposium on Remotely Piloted Vehicles," sponsored jointly by the Electronics Industry Association (EIA) and the Office of the Director of Defense for Research and Engineering (DDR & E). The symposium will be held on May 30, 31, and June 1. During May some efforts will be devoted toward preparing a paper and presentation materials for the symposium.

Respectfully submitted

FOR

Robert P. Zimmer
Project Director

Approved:

H. Allen Ecker
Chief, Radar Division

RPZ:am



GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest Atlanta, Georgia 30332

11 July 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base,
Ohio 45433

Attention: Mr. Leonard Brown
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 11
"Tactical Expendable Assessments"

Gentlemen:

A summary of the progress for the period 1 May through 31 May 1972 is contained herein.

The objectives of the work under this contract are to formulate and to evaluate expendable concepts including associated techniques for delivery, deployment, and possible suspension systems. In the evaluation, emphasis is to be placed on determining if the utilization of such expendable concepts with optimized deployment tactics significantly improves the probability of survival of penetrating aircraft during tactical missions.

General Effectiveness Model (GEM) Efforts

Modeling efforts during May were in the following areas: (1) implementation of the new Operator Sub-Model, (2) initial sensitivity analysis of this Operator Sub-Model, (3) written description of the Operator Sub-Model, (4) monitoring of SATSIM tests, and (5) analysis of preliminary SATSIM data. A brief summary of the efforts in each of these areas is given below.

Implementation (programming) of the current Operator Sub-Model was essentially completed in May. Modules implemented in May included those concerned with tracking, missile-launch, message-sending, and communications links. During initial testing of the various modules, several minor program bugs were encountered. Intermediate program outputs in the form of plots generated with a CALCOMP Plotter were used during initial test runs of GEM to identify problem areas.

Initial sensitivity analyses of the relative probability of survival of aircraft to selected parameters were made to verify that the resulting data

trends agreed with intuition and results obtained previously using GEM-I. Sensitivity of probability of survival to on-board jammer power and to offset distance from the radar were determined. In addition, preliminary sensitivity to the time increment, Δt , was examined.

A rough draft, working version report describing part of the Operator Sub-Model was written in May. The purpose of this report is to document the philosophy used in designing the new Operator Sub-Model as well as to describe those mathematical formulations considered most important in the Operator Sub-Model. Special emphasis was placed upon describing the Basic Operator Module that has been developed by Georgia Tech.

The WRA-1 sponsored SATSIM tests were completed on 19 May 1972. The purpose of these tests was primarily to determine the single-scan probability of acquisition of targets in chaff. Although some tests originally planned were not carried out, data on the most important parameters were collected in sufficient detail to allow future formulation of an "acquisition in chaff" module. Both raw and reduced preliminary data generated from the SATSIM tests have been received by Georgia Tech. Initial examination of single-scan probability of acquisition vs. chaff density data has been made and this data will be used in the formulation of the module. It is anticipated that the remaining data generated by the SATSIM tests will be received in June. Analysis of these data will include plotting of the learning curve of the operators used in the tests to aid in comparing results done during different time periods during the test.

Application of GEM

Analysis efforts during May were devoted primarily toward investigating the vulnerability of a missile fuze to expendable countermeasures (EXCM). A technical report describing this effort is being prepared.

Work continued on the consideration of the drone as a delivery vehicle for expendable countermeasures. Additional computer runs were made to generate data suitable for incorporation into a paper that is being prepared for the symposium on remotely piloted vehicles, sponsored by the Electronic Industries Association (EIA). Based on these data and other related data, a paper entitled, "The RPV as a Delivery Vehicle for Expendable Countermeasures--Some Considerations" was written for the symposium. This paper with some modifications will form the basis for a technical report to be prepared in the future. It should be mentioned that radar cross-section data on drones have not yet been received by Georgia Tech so that survivability aspects of the drone will be considered at a later date.

In anticipation of utilizing GEM-II, efforts were directed toward entering available new data into GEM and checking the accuracy and validity of previously used data. New data that are being entered into GEM include RCS data on the F-4 for vertical and horizontal polarization at three different frequencies.

Interaction

On 3 May 1972, Mr. Robert P. Zimmer presented the RPV paper at a dry run of the symposium sponsored by EIA. The dry run was held at the Institute for Defense Analysis Auditorium in Washington, D. C.

On 11 May 1972, Mr. A. R. Seefluth of Lundy Electronics and Systems, Inc. visited Georgia Tech to discuss the various types of chaff currently in inventory or planned for use by the Navy and Air Force. Mr. Seefluth left several technical memoranda on chaff in which design, frequency response, and packaging considerations were described.

On 18 May 1972, Mr. Robert Zimmer and Mr. Ronald Pearl of Georgia Tech and Mr. Leonard Brown and Mr. George Maxwell visited the Tactical Air Command Headquarters, Langley Air Force Base, Virginia. The primary purpose of this trip was to explore the possibility of AFAL participating in the planning of Coronet Organ exercises that would utilize expendable countermeasures. This meeting was in compliance with the request of Mr. John Porter, DDR&E, that Georgia Tech's TEAS program be used to aid in obtaining the best possible showing of expendables during the Coronet Organ exercises. The attendees from TAC were the following: LTC Housum (DOOF), Maj. Lewis (XPSC), Maj. Rich (XPSC), Maj. Harkavy (OAY), Maj. Moran (INOV), Maj. McLaughlin (DRR), and Sgt. Push (LGMA). Mr. Maxwell opened the meeting by requesting that the meeting be a working session centered around the Coronet Organ exercises. He then gave background of the TEAS program and Mr. Zimmer gave highlights of the approach and capabilities of TEAS. Mr. Maxwell then related AFAL's administrative and planning experiences of using expendables in the Coronet Organ V exercises. After some discussion about contractors participation in these exercises and the need for AFAL planning, it was concluded that a request by AFAL should be submitted to TAC/DRR for approval. The meeting lasted about 45 minutes.

Effort Expended

Work during 1 May through 31 May was performed by the following professional personnel:

<u>Name</u>	<u>May Hours</u>	<u>Cumulative Hours</u>
Ecker, H. Allen Principal Research Engineer	28	346
Flynt, Edward R. Principal Research Engineer	92	161
Francis, O. B., Jr. Research Mathematician	150	1103
Greneker, E. F. Assistant Research Scientist	147	770
Miller, Thomas M., Jr. Research Engineer	63	1191
Pearl, Ronald G. Assistant Research Engineer	144	1397
Sears, W. E., III Research Engineer	140	1455
Zimmer, Robert P. Project Director	140	1489

Future Work

During June efforts will be devoted toward (1) verification of GEM-II, (2) development of complex scenarios for analysis, (3) analysis of SATSIM test results, (4) preliminary investigation of the QRC-335 jammers, and (5) preparation of interim technical reports.

In the verification of GEM-II, particular emphasis will be placed on determining how well the modules associated with strobes reflect anticipated operator responses. Sensitivity analyses will be performed using at first simple many-on-one scenarios for which data trends are generally predictable and then using more complex scenarios involving several aircraft against several types of sites. Should any programming changes be necessary the verification procedure will be repeated.

While the above work on GEM-II is being performed other efforts will be devoted toward selecting complex scenarios that are both realistic and suitable for analysis using GEM-II. These scenarios and the desired format of the analysis results will be discussed with various Air Force personnel so that future results will reflect the interests of the using commands.

It is anticipated that all remaining data generated by the WRA-1 SATSIM tests will be received in June. When this data are received another task concurrent with the others will be to analyze the data using curve-fitting techniques so that it is in a form suitable for incorporation into GEM-II. The resulting formulation will then be implemented into the GEM program.

In recognition that the QRC-335 will be perhaps the most widely used on-board jammer, a review will be made during June of the various QRC-335 modes to determine to what extent these modes can or should be modeled in GEM-II.

During June preparation of three interim technical reports will be completed. These three reports will describe the work on (1) consideration of the drone as a delivery vehicle for expendables, (2) preliminary analysis of a missile fuze jammer, and (3) preliminary analysis of area expendables.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. Allen Ecker
Chief, Radar Division

RPZ:jf

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ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

15 December 1972

Air Force Avionics Laboratory (WRA)
Wright-Patterson Air Force Base
Ohio 45433

Attention: Mr. Leonard Brown
Electronic Warfare Division

Reference: Contract F33615-71-C-1885

Subject: Monthly Status Report No. 17
"Tactical Expendable Assessment Study (TEAS)"

Gentlemen:

A summary of the progress for the period 1 November through 30 November 1972 is contained herein.

Efforts during November were devoted primarily toward (1) preparation of a report summarizing the work performed in support of the Mission Analysis Force (MAF) on Electronic Warfare Goals; (2) preparation of presentation material for briefings to the MAF and to Headquarters, USAF; (3) investigation of ring-around jamming, and (4) preparation of plans for future work.

A working paper report entitled, "Investigation of Expendable Countermeasures for the Mission Analysis Force on Electronic Warfare" was written and delivered to MAF. Considerable effort went into organizing all the data that had been gathered or generated and describing it in report form. In the report, the analysis approach was described in detail since for much of the work deductive reasoning was used to draw conclusions about the potential effectiveness of expendables against future threats. This working paper will be published as Interim Technical Report No. 5 on the current contract.

Based on the organization of the working paper, a presentation was prepared that described the background, analysis approach, conclusions, and recommendations. Viewgraphs were prepared for use as a visual aid in the presentation to the MAF.

Georgia Tech was requested to give a presentation to Headquarters, USAF and also to Headquarters, AFSC during November. In preparation for these briefings, past TEAS efforts were reviewed and appropriate view-graphs were prepared.

Investigation of ring-around jamming continued with an anticipated completion date being 15 December. The alternative jamming techniques as proposed by various manufacturers are being analyzed to identify problem area and to evaluate proposed solutions to these problems and new problems arising out of the proposed solutions. Relative advantages and disadvantages of each technique are being considered to provide a basis for selecting the techniques most desirable for future development.

Preliminary plans were prepared for the investigation of the TPAR concept and for possible work during the 1973 Calendar Year. These plans when formulated more completely will be discussed with AFAL personnel.

Visits

On 8 November Mr. Ronald Pearl and Mr. William Sears of Georgia Tech visited Wright-Patterson Air Force Base to give a briefing to the Mission Analysis Force on Electronic Warfare Goals. Mr. Pearl presented a summary of the work performed during the months of September and October in support of the Mission Analysis Force. The attendees included Mssrs. O. J. Schulte, J. Meli, G. Maxwell, J. Danish, L. Brown, Lt. Col. D. Wyrick and Major L. Bowman.

On 13 November 1972, Mr. R. G. Pearl and Mr. W. E. Sears along with Mr. Leonard Brown of AFAL visited the Headquarters, AFSC at Andrews Air Force Base, Maryland. Mr. Phil Sandler co-ordinated the briefing. In the morning, a one hour briefing of past and current efforts on the TEAS program was presented. In attendance were Mr. Philip Sandler, Col. D. D. Christofferson, Major E. A. Koch, Major R. H. Seh, Major S. F. Somma, Lt. Col. M. R. McLaughlin, Col. D. C. Kipfer, Lt. Col. T. R. Bogan, and Mr. J. R. Murray. The briefing included a statement of the goals of the TEAS program, a brief background of GEM, a summary of past results, and a schedule of tasks for the Mission Analysis Force on Electronic Warfare Goals.

During the afternoon of 13 November 1972, Mssrs. Robert Zimmer, Ronald Pearl, William Sears, and Mr. Leonard Brown (AFAL/WRA) visited Headquarters, USAF/RDRE in Washington, D. C. to give a presentation of the TEAS program.

Major Warren Cook co-ordinated the briefing, which was essentially the same as that given at AFSC. Other attendees were Col. (B/G) Hodnette, Col. B. Lieber, Col. P. Pahl, Col. D. Vechik, and Major E. A. Koch (AFSC/DLCA).

On 14 November 1972, Mr. John Porter (OSD) visited Georgia Tech to discuss expendable countermeasures. Essentially the same briefing as given to Headquarters, USAF on 13 November 1972 was presented. Attendees were Dr. H. A. Ecker, Mr. Robert P. Zimmer and Mr. Ronald G. Pearl.

On 15 November 1972, Mr. Walter Schwartz of Tasker/ERI visited Georgia Tech to interchange information on the various expendables being developed by Tasker.

On 17 November, Mr. Robert Zimmer visited AFAL and met separately with Mr. Leonard Brown, Mr. Joseph Hoffman, and Mr. Joseph Meli. Plans concerning the effort on ring-around jamming were discussed with Mr. Hoffman and the final supporting data for the Mission Analysis effort were delivered to Mr. Meli.

Effort Expended

Work during 1 November through 30 November was performed by the following professional personnel:

<u>Name</u>	<u>November Hours</u>	<u>Cumulative Hours</u>
Cooke, William P. Assistant Research Engineer	160	881
Ecker, H. Allen Principal Research Engineer	48	619
Flynt, Edward R. Principal Research Engineer	146	1094
Francis, O. B., Jr. Research Mathematician	141	1971
Greneker, E. F. Assistant Research Scientist	138	1577

Effort Expended (Continued)

<u>Name</u>	<u>November Hours</u>	<u>Cumulative Hours</u>
Pearl, Ronald G. Research Engineer	152	2264
Sears, W. E., III Research Engineer	58	2275
Zimmer, Robert P. Project Director	122	2298

Future Work

During December, efforts will be devoted primarily toward (1) completion of the preliminary investigation of ring-around jamming, (2) initial efforts on investigation of the TPAR concept, and (3) documentation of the operator model of GEM. A presentation on the ring-around jamming will be given and a report summarizing the investigation will be completed during December. Initial efforts on the TPAR investigation will consist of preparing detail plans outlining the approach, anticipated parametric analyses, and corresponding schedule. The documentation of the operator model is a continuation of the effort that was suspended in June. It is anticipated that the report will be completed in January and that this report will serve as input to the Final Report.

Because of the holiday schedule during December, the effort expended will be somewhat lower than usual. Regular holidays for Georgia Tech are 25 - 29 December; in addition to these holidays, additional days of vacation will be taken by TEAS personnel.

Respectfully submitted,

Robert P. Zimmer
Project Director

Approved:

H. Allen Ecker
Chief, Radar Division

RPZ:bp